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Thin-type picture display device.

Flat, thin picture display device (1) having a transparent face plate (3) and a rear plate (4) and a large number of electron sources (5) and local electron transport ducts (11) cooperating therewith, a selection plate (10) arranged at a distance between the face plate (3) and the rear plate (4) having an arrangement of apertures (8) which defines locations for withdrawing electrons from the electron transport ducts (11) and, aligned therewith, a row of apertures defining locations for the electron sources.

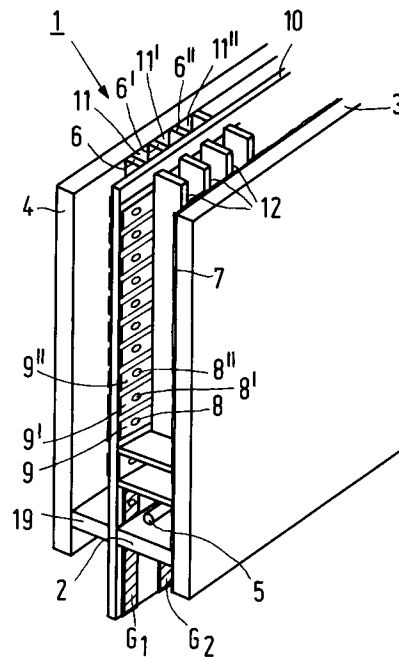


FIG. 1

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The invention relates to a picture display device having a vacuum envelope for displaying pictures composed of pixels on a luminescent screen, and particularly relates to a thin picture display device (i.e. a picture display device having a small "front-to-back dimension") which is clearly distinguished from state-of-the-art display devices.

Typical state-of-the-art approximations to thin-type picture display devices are devices having a transparent face plate and a rear plate which are interconnected by means of partitions and in which the inner side of the face plate is provided with a phosphor pattern, one side of which is provided with an electrically conducting coating (the combination also being referred to as luminescent screen). If (video information-controlled) electrons impinge upon the luminescent screen, a visual image is formed which is visible via the front side of the face plate. The face plate may be flat or, if desired, curved (for example, spherical or cylindrical).

A specific category of picture display devices of the thin type uses single or multiple electron beams which initially extend substantially parallel to the plane of the display screen and are ultimately bent towards the display screen so as to address the desired areas of the luminescent screen either directly or by means of, for example, a selection grid structure. (The expression electron beam is understood to mean that the paths of the electrons in the beam are substantially parallel, or extend only at a small angle to one another and that there is a main direction in which the electrons move). The above-mentioned devices operating with controlled electron beams require, *inter alia*, complicated electron-optical constructions.

Moreover, picture display devices of the single beam type generally require a complicated (channel plate) electron multiplier of the matrix type, certainly if they have slightly larger screen formats.

In view of the foregoing it is an object of the invention to provide a thin-type picture display device which substantially does not have the drawbacks of the above-mentioned devices.

According to the invention, a picture display device having a vacuum envelope for displaying pictures composed of pixels on a luminescent screen therefore comprises a plurality of juxtaposed sources for producing electrons, local transport ducts cooperating with the sources and having walls of electrically substantially insulating material having a secondary emission coefficient suitable for transporting produced electrons in the form of electron currents, and first selectively energizable electrode means for withdrawing each electron current from its transport duct at predetermined extraction locations and directing them towards the

luminescent screen for forming a picture composed of pixels, a selection plate system arranged at a distance between the front and rear walls by means of front and rear spacers having a main surface with an arrangement of apertures defining the extraction locations and, aligned therewith, a row of apertures defining electron source locations.

The inventive approach of providing a thin-type picture display device is based on the discovery that electron transport is possible when electrons impinge on an inner wall of an elongate evacuated cavity (so-called compartment) defined by walls of electrically substantially insulating material (for example, glass or synthetic material) if an electric field of sufficient power is realised in the longitudinal direction of the compartment (for example, by applying an electric potential difference across the ends of the compartment). The impinging electrons then generate secondary electrons by wall interaction which are attracted to a further wall section and in their turn generate secondary electrons by wall interaction. As will be further described, the circumstances (field strength E , electrical resistance of the walls, secondary emission coefficient δ of the walls) may be chosen to be such that a constant vacuum current will flow in the compartment.

Starting from the above-mentioned principle, a flat picture display device can be realised by providing each one of a plurality of juxtaposed compartments constituting transport ducts with a column of apertures constituting extraction locations at one side to be directed towards a display screen. In this case it is practical to arrange the extraction locations of adjacent transport ducts along parallel lines extending transversely to the transport ducts. By associating row-sequentially arranged electrode means to the arrangement of apertures, which means are energizable by means of a first (positive) electric voltage (pulse) so as to withdraw electron currents from the compartments via the apertures of a row, or which are energizable by means of a second (lower) electric voltage if no electrons are to be locally withdrawn from the compartments, an addressing means is provided with which electrons withdrawn from the compartments can be directed towards the screen for producing a picture composed of pixels.

To ensure that the device according to the invention can be manufactured with a minimum of alignment problems, it specifically has a selection plate positioned between the front and rear walls and having an aperture pattern defining both the extraction locations and the locations of the electron sources.

Such a structure can be easily made with a sufficiently great accuracy by means of, for example, lithographic techniques. Electrically conducting

strips having apertures aligned with the apertures in the plate and constituting electrode means for selectively withdrawing electrons from the apertures can be easily provided on the structure by means of, for example photolithographic techniques. Since in the construction described above the locations of the electrons impinging upon the luminescent screen (the "spots") are defined by the apertures in the selection plate, the other components which are used, such as the spacers, may be made with less precise accuracy, which has a cost-saving effect. Nevertheless a very high resolution can be achieved because the selection plate itself can be made with very great accuracy.

An important elaboration of the above-described principle is characterized in that the selection plate system has supporting means at its side facing the luminescent screen, which means support the arrangement of electron sources for cooperating with the transport ducts.

To be able to drive the electron sources individually, strip-shaped drive electrodes each having an aperture which is aligned with one of the apertures defining the electron source locations are preferably arranged on a main surface of the selection plate system.

For a simple electric connection an embodiment is characterized in that the electron source arrangement is present proximate to an edge of the main surface and in that a strip-shaped electron source drive electrode provided on the main surface is associated with each aperture defining an electron source location, which electrode extends from said aperture into the direction of said edge, while it is particularly advantageous if said edge extends beyond at least one of the partitions connecting the front and rear walls. Drive circuits (possibly in chip form - "chip on glass") may be arranged between the ends of the drive electrodes and the edge. These circuits may be present within or outside the vacuum envelope.

As already noted hereinbefore, it is practical to arrange the apertures in the selection plate along rows extending transversely to the transport ducts. In this case the front (screen-sided) spacer preferably comprises a system of mutually parallel walls which extend between the apertures at an angle to the rows of apertures.

As will be further described, it may be advantageous, in connection with the available space, for the walls of the system to extend transversely to the rows of apertures.

If the "horizontal" resolution is to be decreased without reducing the pitch of the transport ducts, a possibility is provided by an embodiment which is characterized in that each extraction location is defined by at least a first and a second aperture and in that the first selectively energizable elec-

trode means comprise at least a first system of sub-electrodes for line-sequentially driving the first apertures and a second system of sub-electrodes for line-sequentially driving the second apertures.

5 Colour display is possible in different manners with the device according to the invention. A constructive simple embodiment is characterized in that the number of parallel rows is three times as large for colour display as the number of lines of a picture to be displayed and corresponds to the number of phosphor lines on the luminescent screen. When there are n picture lines, $3n$ electric connections and drive circuits are required in the most general case.

10 An alternative embodiment which is simpler in an electrical respect is characterized in that the selection plate system comprises two sub-selection plates which are spaced apart:

15 one preselection plate facing the rear wall and having apertures defining the extraction locations and the electron source locations; and

20 one fine selection plate facing the front wall and having at least two apertures associated with each extraction location in the preselection plate.

25 If there are, for example, $\frac{n}{m}$ rows of preselection apertures in the preselection plate and $3m$ fine selection apertures for each preselection aperture, only $\frac{n}{m} + 3m$ connections/drive circuits are sufficient in the case of colour display of n picture lines on the screen. Consequently, if m is chosen to be 3, 201 instead of 1728 connections/drive circuits are required for displaying 576 picture lines.

30 Some embodiments of the invention will be described in greater detail with reference to the drawings in which the same reference numerals are used for corresponding components.

35 Fig. 1 is a diagrammatic perspective elevational view, partly broken away, of a part of a construction of a picture display device according to the invention whose components are not drawn to scale;

40 Fig. 2 is a side elevation, broken away, of the construction of Fig. 1 to illustrate the general operation of the invention;

45 Fig. 3 shows the operation of a specific electron transport duct to be used in the construction of Fig. 1 with reference to a "vertical" cross-section;

50 Fig. 4 shows a graph in which the secondary emission coefficient δ as a function of the primary electron energy E_p is plotted for a wall material which is characteristic of the invention;

55 Fig. 5 shows the selection plate 10 of the device shown in Fig. 1, provided with a characteristic (selection) electrode arrangement;

Fig. 6A is an elevational view of a cross-section and Fig. 6B is an elevational view of a longitudinal section through a holder supporting the de-

vice of Fig. 1;

Fig. 7 shows an alternative embodiment of a selection plate 10 for the device shown in Fig. 1; and

Fig. 8 shows a double selection plate construction by way of a cross-sectional view.

Fig. 1 shows a thin-type picture display device 1 according to the invention having a front wall (window) 3 and a rear wall 4 located opposite said front wall. An electron source arrangement 5, for example, a line cathode which by means of electrodes G1, G2, ... provides a large number of electron emitters, for example 600, is arranged proximate to a wall 2 which connects front wall 3 and rear wall 4. A corresponding number of separate electron emitters may alternatively be used. Each of these emitters is to provide a relatively small current so that many types of cathodes (cold or thermal cathodes) are suitable as emitters. The emission is preferably controlled by means of the video signal. An alternative is to apply the video information to a gating structure arranged subsequent to the electron source arrangement, (for example, a line cathode in this case) instead of to the emitters. The electron source arrangement 5 is arranged opposite to entrance apertures of a row of transport ducts 11, 11', 11'' extending substantially parallel to the screen, which ducts are defined by compartments 6, 6', 6'', ... etc. in this case one compartment for each electron source. One of these compartments is shown in a cross-section in Fig. 3.

At least one wall (preferably the rear wall) of each compartment is made of a material which has a suitable electrical resistance for the purpose of the invention (for example, ceramic material, glass, synthetic material - coated or uncoated) and which has a secondary emission coefficient $\delta > 1$ over a given range of primary electron energies (see Fig. 4). The electrical resistance of the wall material has such a value that a minimal amount of current will flow in the walls in the case of a field strength (E_y) in the compartments of the order of one hundred to several hundred Volts per cm, required for the electron transport. Currents as low as 1 micro-ampere have been found to be realisable. By applying a voltage of the order of several dozen to several hundred Volts (value of the voltage is dependent on circumstances) between an electron source 5 and a compartment, electrons are accelerated from the electron source 5 towards the compartment 6 whereafter they generate secondary electrons in the compartment by wall interaction (see Fig. 3).

The invention is based on the recognition that vacuum electron transport within compartments having walls of electrically insulating material is possible if an electric field (E_y) of sufficient power

is applied in the longitudinal direction of the compartment. Such a field realises a given energy distribution and spatial distribution of electrons injected into the compartment so that the effective secondary emission coefficient δ_{eff} of the walls of the compartment will be equal to 1 on average in operation. Under these circumstances one electron will leave for each electron which enters (on average), in other words, the electron current is constant throughout the compartment and is approximately equal to the current which enters. If the wall material is high-ohmic enough (which is the case for all appropriate untreated glass types, as well as for kapton, pertinax and ceramic materials), the walls of the compartment cannot produce or take up any net current so that this current, even in a close approximation is equal to the entering current. If the electric field is made larger than the minimum value which is required to obtain $\delta_{\text{eff}} = 1$, the following will happen. As soon as δ_{eff} is slightly larger than 1, the wall is charged inhomogeneously positively (due to the very small conductance this charge cannot be depleted) As a result, the electrons will reach the wall earlier on average than in the absence of this positive charge, in other words, the average energy taken up from the electric field in the longitudinal direction will be smaller so that a state with $\delta_{\text{eff}} = 1$ adjusts itself. This is a favourable aspect because the exact value of the field is not important, provided that it is larger than the previously mentioned minimum value.

Another advantage is that in the state $\delta_{\text{eff}} \approx 1$ the electron current in the compartment is constant and can be made to be very satisfactorily equal via measuring and feed-back or via current control for each compartment so that a uniform picture can be realised on the luminescent screen.

The compartment walls facing the luminescent screen 7, which is arranged on the inner wall of the panel 3, are constituted by a selection plate 10 (see Fig. 2). This plate 10 has extraction apertures 8, 8', 8'', etc. which define extraction locations. Provided that specific provisions have been made, a "gating" structure can be used to "withdraw" a flow of electrons from a desired aperture when using cathodes which are not separately driven. However, cathodes which are individually driven by means of electrodes G1, G2, ... are preferably used in combination with apertured selection electrodes 9, 9', 9'', (see also Fig. 5) to be energized by a selection voltage. In the Fig. 1 construction they are formed as strip pairs having apertures which face each other, with the strips of one pair being always arranged opposite each other on the facing main surfaces of the plate 10. The apertures of the strip pairs are aligned with the apertures in the plate 10. The facing strips are preferably interconnected electrically via the apertures 8, 8', 8''. To

realise this, for example, an apertured plate 10 may be electroless nickel-plated, whereafter a strip pattern is formed from the electroless nickel-plated layer by means of etching. These selection electrodes 9, 9', 9'', which may alternatively be provided on only one of the main surfaces of plate 10, are implemented for each picture line, for example in the way shown in Fig. 5 ("horizontal" electrodes 9, 9', 9'', ... with apertures coaxial with the apertures 8, 8', 8'', ...). The apertures in the electrodes 9, 9', 9'', ... will generally be at least as large as the apertures 8, 8', 8'', If they are larger, aligning will be easier. Desired locations on the screen 7 can be addressed by means of (matrix) drive of the individual cathodes and the selection electrodes 9, 9', 9'',

For example, voltages which increase substantially linearly (as viewed from the cathode side) are applied to the selection electrodes 9, 9', 9'', When a picture line must be activated, i.e. when electrons must be withdrawn via apertures in an aperture row from the column-wise arranged electron currents flowing behind them, a pulsatory voltage ΔU is added to the local voltage. In view of the fact that the electrons in the compartments 6, 6', 6'', ... have a relatively low velocity due to the collisions with the walls, ΔU may be comparatively low (of the order of, for example 100 V to 200 V). In this case a voltage difference V_a is taken across the total compartment height, which is just too small to draw electrons from apertures. This does happen by applying a positive line selection pulse of the correct value.

Selection plate 10 is spaced apart from the front wall 3 and the rear wall 4. In the construction shown in Figs. 1 and 2 the side walls of the compartments 6, 6', 6'', ... are used as rear spacers to keep the plate 10 spaced apart from the rear wall 4 and "vertical" walls 12 extending transversely to the front wall 3 are provided which are used as front spacers for spacing the plate 10 apart from the front wall 3. In this way a satisfactory vacuum support is realised. In most cases the "horizontal" pitch P_H between the apertures 8, 8', 8'', will be larger than the "vertical" pitch P_V (for example, 1.3 mm and 1 mm, respectively, in the case of monochrome display and 1.3 mm and 0.33 mm, respectively, in the case of colour display) so that it is advantageous in connection with the space to arrange the walls 12 "vertically" (see also Fig. 5). The walls 12 need not be absolutely "vertical", i.e. transverse to the rows of selection electrodes 9, 9', 9'', but they may alternatively extend parallel to the row selection electrodes 9, 9', 9'',

The ("vertical") walls 12 are preferably made of a material manufactured by a 2nd cross-over point E_{II} of the secondary emission coefficient δ which is so low that there is no unwanted field emission (see Fig. 4). For example, macor and

window glass have been found suitable.

To prevent penetration of the accelerating field to be applied between the luminescent screen 7 and the plate 10 through the apertures 8, 8', 8'',, which could lead to contrast problems, it is preferable to choose the dimensions of the apertures 8, 8', 8'', to be sufficiently small. Another possibility is the use of a fine-meshed gauze between the plate 10 and the front wall 3.

Figs. 2 and 5 show a plurality of further constructive details which may be present in the display device of Fig. 1:

A contact track 13 provided on the front wall 3 for electrically contacting of the luminescent screen.

Electrodes 15, 16 arranged on the rear wall 4 and on the bottom of the electron transport compartments 6, 6', 6'', for helping the electron transport;

Measuring strips 17a, 17b arranged in the plate 10 opposite apertures 18a, 18b ... provided with extraction electrodes for checking the uniformity of the electron currents produced in the transport ducts 11, 11', 11'',

Cover plates 19a, 19b, 19c;

A lead-in electrode 20 (approximately 1 mm high);

A shielding face 21.

An electron source arrangement 5. This may be, for example, a line cathode whose extremities are suspended on the partitions or which is supported by supporting means (not visible in the Figure) arranged on the plate 10. Instead of a line cathode, separate electron emitters, for example p-n emitters secured on the plate 10 may be used. The reference numeral 25 denotes a shielding means for the electron source arrangement. The electron source arrangement 5 is arranged opposite a row of apertures 26, 26', 26'' , which are aligned with the arrangement of extraction apertures 8, 8', 8'',

An example of connecting the various electrodes is shown in Fig. 6A which is an elevational view of a cross-section through a holder supporting the device of Fig. 1, and Fig. 6B which is an elevational view of a longitudinal section through the holder 30. External connectors are denoted by the reference numerals 31, 32 and 33. For example, the selection electrodes 9, 9', 9'', are implemented in such a way that the selection electrodes having an odd ordinal number extend as far as the left edge of selection plate 10 and the selection electrodes having an even ordinal number extend as far as the right edge of selection plate 10 (see Fig. 5). This simplifies the connection with the connectors 32, 33. The emitter drive electrodes G_1 , G_2 ... extend as far as the lower edge of the plate 10 and are connected to connector 31.

Fig. 7 shows diagrammatically a part of a selection plate 10 constituting the front wall of transport ducts 11, 11', 11'', with a pitch P. In the embodiments shown the horizontal picture resolution is determined by the pitch of the transport ducts. A better resolution can thus be obtained by making this pitch smaller. However, this has the drawback that the voltage drop across the ducts required for transporting the electron currents will increase, which is not always desirable. This problem can be solved by leaving the pitch of the transport ducts unchanged and by giving the spacer structure the required smaller pitch, combined with an adapted pattern of the selection apertures and electrodes, as will be illustrated with reference to Fig. 7.

Fig. 7 shows two extraction apertures for each extraction location so that the pitch of the spacer walls is half ($p/2$) that of the transport ducts (p). Each selection electrode 29 is divided into two apertured sub-electrodes 30a and 30b in the manner shown, which simplifies contacting. In this way the horizontal resolution can be doubled with respect to the construction shown in Fig. 1, while the transport ducts 11, 11', 11'' can be controlled by the same voltages and in the same manner.

To operate the display device according to the invention in an advantageous mode, a well-defined electric voltage increasing from the cathode side is to be applied particularly across the front and rear walls of the transport ducts, the voltage on the front wall always being slightly lower at the same height. This can be realised, for example, by adjusting the wall potential by means of a high-ohmic resistance layer provided on the relevant wall, such as the resistance layer 24 (Fig. 2) provided on the rear wall, and the electric contacts (22 and 23 in Fig. 2) contacting the resistance layer are used for connection to a voltage source. This resistance layer may have a meandering or zigzag pattern for increasing the resistance. The front wall potential may be adjusted by arranging strip-shaped electrodes on the inner side of the front walls of the transport ducts and giving them, in operation, a (substantially linearly) increasing potential. These electrodes may also be used advantageously for (picture) line selection by providing them with apertures aligned with the apertures in the preselection plate and connecting them to a circuit for providing a (positive) selection voltage.

Fig. 8 shows diagrammatically a selection plate system having a preselection plate 10a with preselection apertures 41 and a screen-sided fine selection plate 10b arranged at a distance therefrom.

For the purpose of colour selection three apertures 42, 42', 42'' in the fine selection plate 10b are associated with each aperture 41, which ap-

ertures are drivable by means of fine selection electrodes 43, 43', 43'', respectively. This provides the possibility of arranging the fine selection electrodes of corresponding apertures electrically parallel, for example, by means of coupling capacitors. If the preselection plate 10a has, for example, 200 rows of apertures, no more than 203 electric connections are required for displaying 600 picture lines on the screen in the case of monochrome display.

Plate 10a may be implemented like plate 10 in Fig. 7.

It is to be noted that "vertical" transport ducts and "horizontally" arranged rows of extraction apertures/selection electrodes are described in the previous embodiments. Instead, the transport ducts may alternatively extend "horizontally" in combination with a "vertical" arrangement of rows of extraction apertures/selection electrodes. In the latter case picture memories for driving the electrodes in the correct manner may be used.

Claims

1. A picture display device having a vacuum envelope with a transparent face plate whose inner surface is provided with a luminescent screen for displaying pictures composed of pixels and a rear plate connected to the face plate by means of partitions, said device comprising an arrangement of juxtaposed sources for producing electrons, local transport ducts cooperating with the sources and having walls of electrically substantially insulating material having a secondary emission coefficient suitable for transporting produced electrons in the form of electron currents, and first selectively energizable electrode means for withdrawing each electron current from its transport duct at predetermined extraction locations and directing them towards the luminescent screen for forming a picture composed of pixels, a selection plate system arranged at a distance between the front and rear walls by means of front and rear spacers having a main surface with an arrangement of apertures defining the extraction locations and, aligned therewith, a row of apertures defining electron source locations.
2. A device as claimed in Claim 1, characterized in that the selection plate system has supporting means at its side facing the luminescent screen, which means support the arrangement of electron sources for cooperating with the transport ducts.
3. A device as claimed in Claim 1, characterized

- in that strip-shaped electron source drive electrodes are arranged on a main surface of the selection plate, each electrode having an aperture which is in alignment with one of the apertures defining the electron source locations. 5
4. A device as claimed in Claim 3, characterized in that the electron source arrangement is present proximate to an edge of the main surface and in that a strip-shaped electron source drive electrode arranged on the main surface is associated with each aperture defining an electron source location, which drive electrode extends from said aperture into the direction of said edge. 10 15
5. A device as claimed in Claim 4, characterized in that the edge at which the electron source arrangement is present extends beyond at least one of the partitions connecting the front and rear walls. 20
6. A device as claimed in Claim 1, characterized in that the apertures of adjacent transport ducts defining the extraction locations are arranged along parallel lines extending transversely to the transport ducts. 25
7. A device as claimed in Claim 6, characterized in that the front spacer comprises a system of mutually parallel walls extending between the apertures at an angle to the rows of apertures. 30
8. A device as claimed in Claim 6, characterized in that the walls of the system extend transversely to the rows of apertures. 35
9. A device as claimed in Claim 8, characterized in that each extraction location is defined by at least a first and a second aperture and in that the first selectively energizable electrode means comprise at least a first system of sub-electrodes for line-sequentially driving the first apertures and a second system of sub-electrodes for line-sequentially driving the second apertures. 40 45
10. A device as claimed in Claim 6, characterized in that the number of parallel rows is three times as large for colour display as the number of lines of a picture to be displayed and corresponds to the number of phosphor lines on the luminescent screen. 50 55
11. A device as claimed in Claim 1, characterized in that the selection plate system comprises two sub-selection plates which are spaced apart:
- one preselection plate facing the rear wall and having apertures defining the extraction locations and the electron source locations; and
 - one fine selection plate facing the front wall and having at least two apertures associated with each extraction location in the preselection plate.

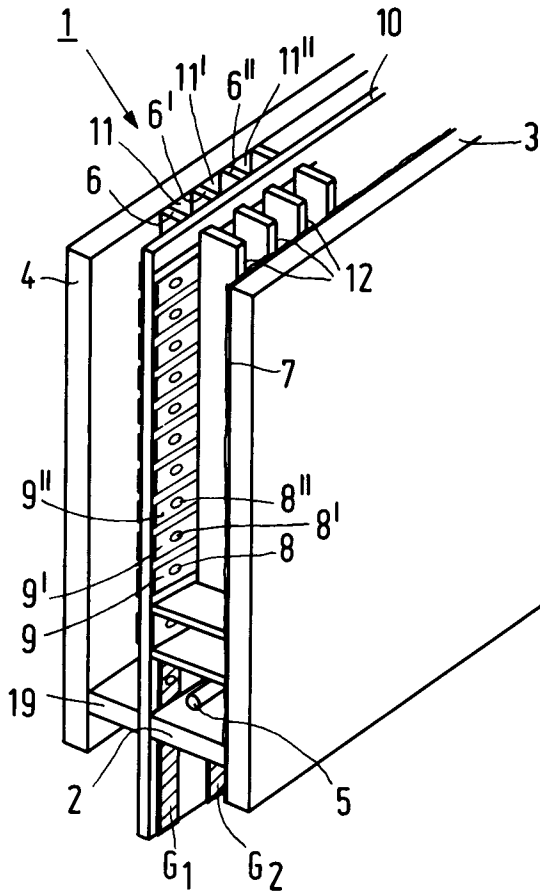


FIG. 1

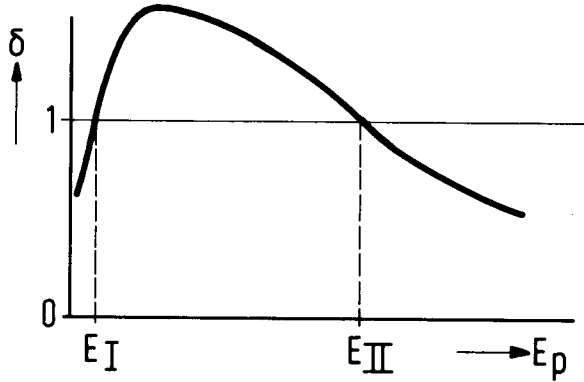


FIG. 4

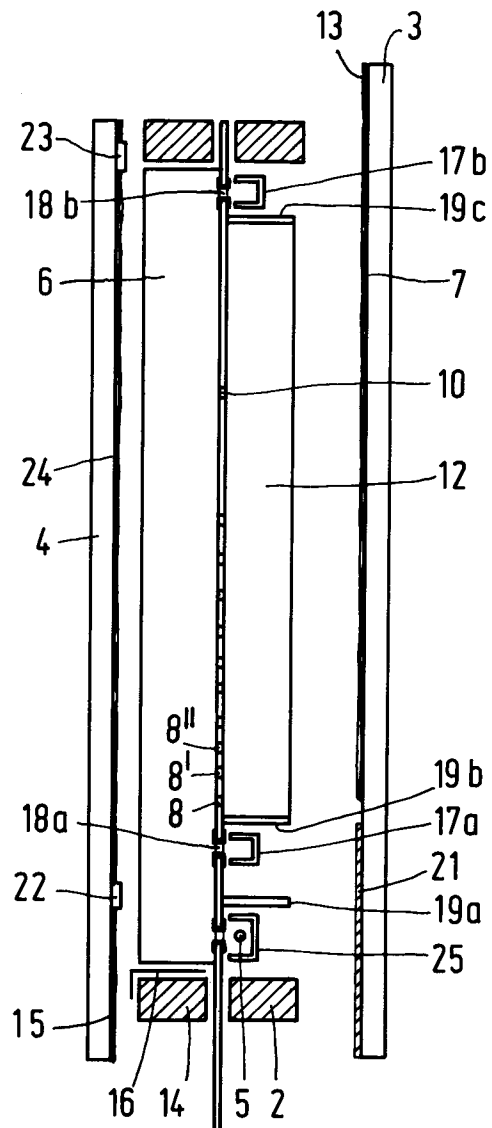


FIG. 2

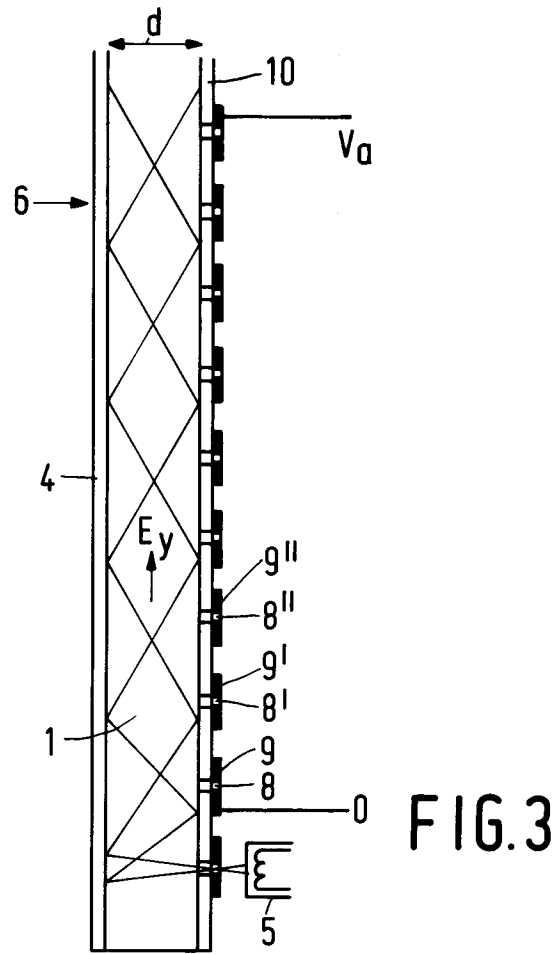


FIG. 3

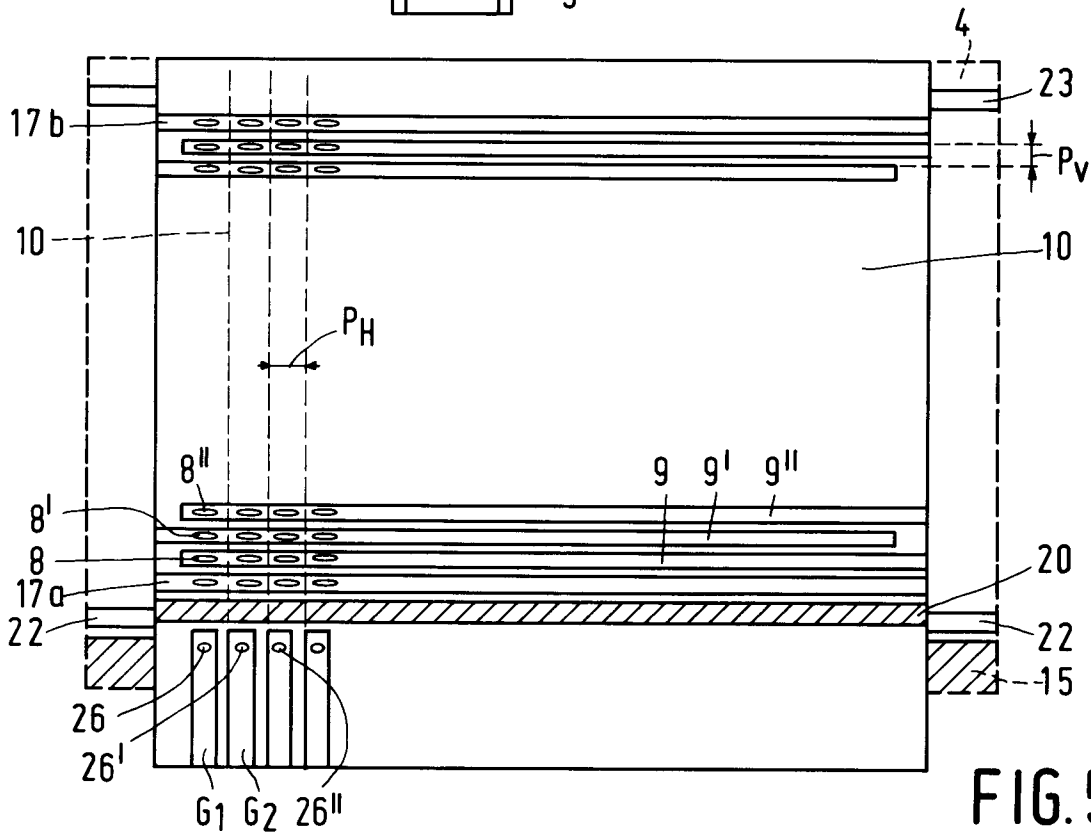


FIG. 5

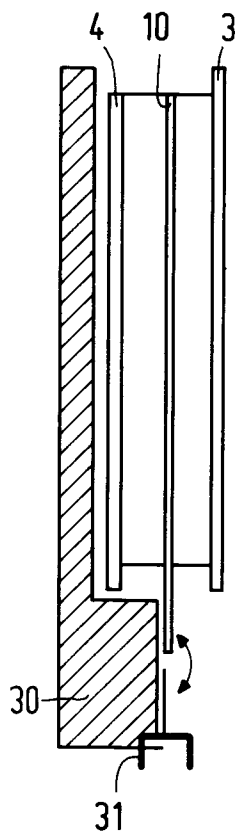


FIG. 6A

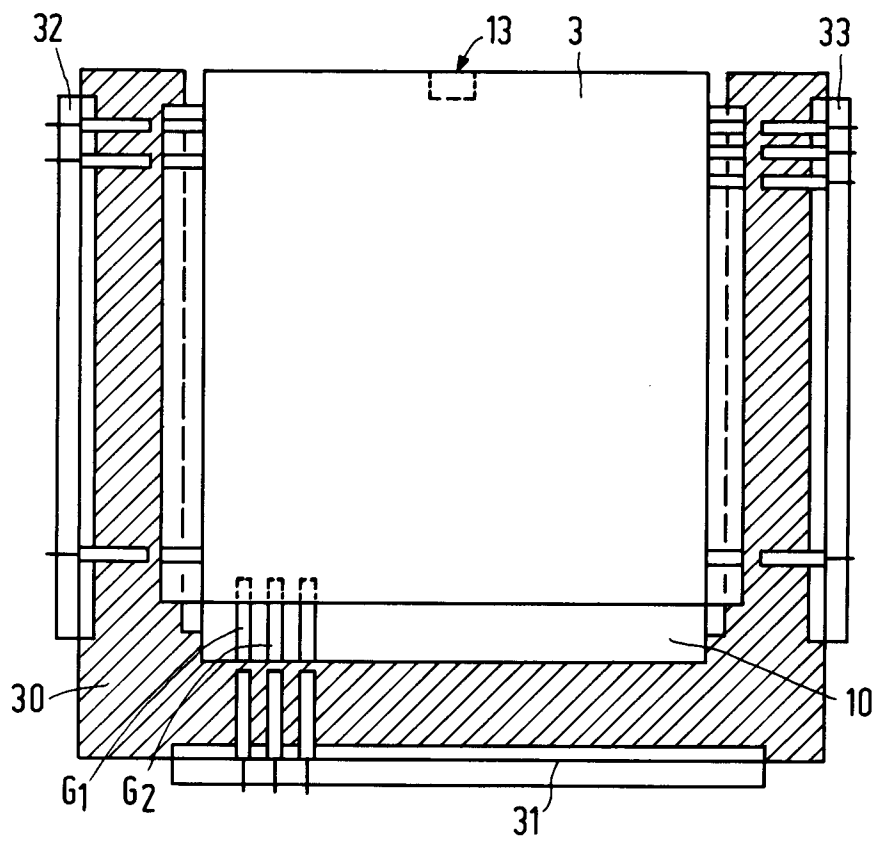


FIG. 6B

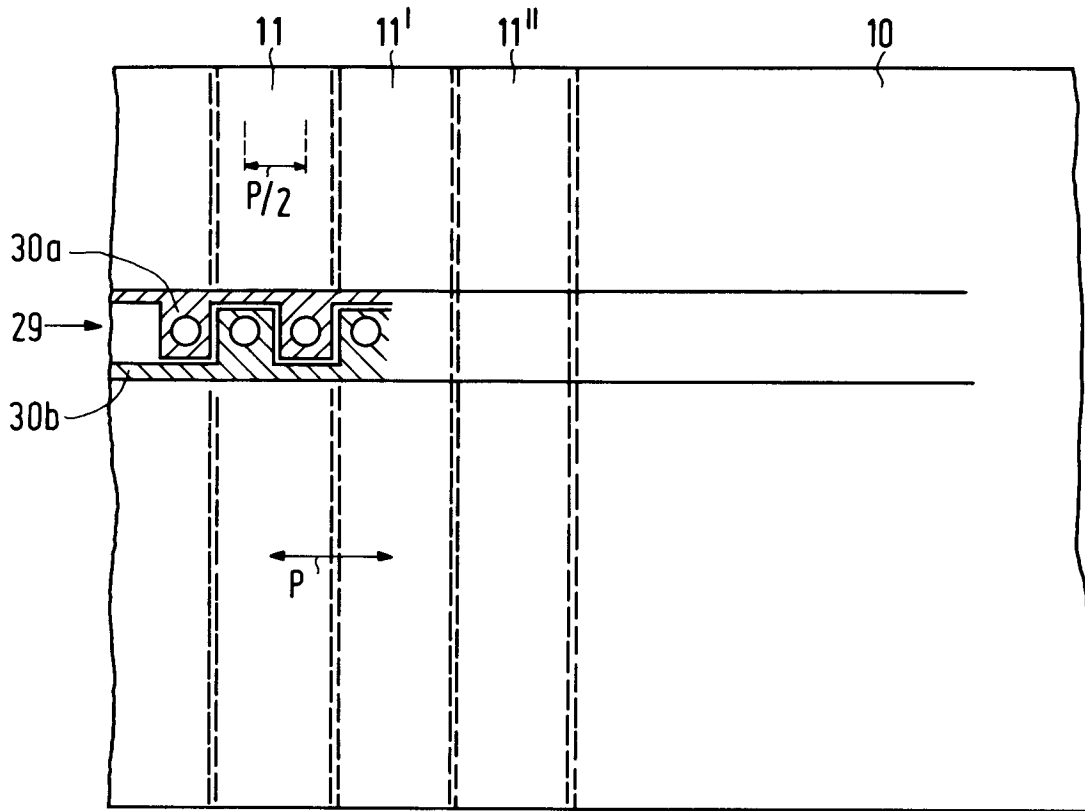


FIG. 7

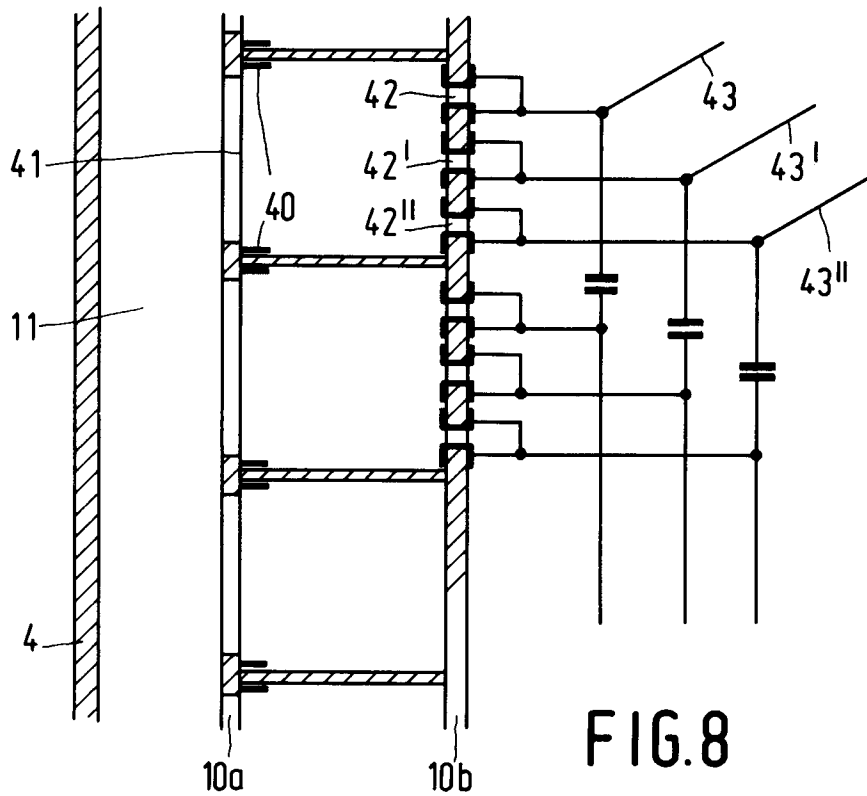


FIG. 8



EUROPEAN SEARCH
REPORT

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 079 108 (PHILIPS) * page 2, line 29 - page 3, line 10 ** page 5, line 12 - line 21 ** page 5, line 25 - line 27; figure 1 *	1	H 01 J 31/12
A	US-A-4 069 439 (C.ANDERSON) * column 3, line 1 - line 6 ** column 4, line 56 - line 60; figures 1,2 *	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 01 J
Place of search The Hague	Date of completion of search 20 September 91	Examiner ROWLES K.E.G.	
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